FIG. 1

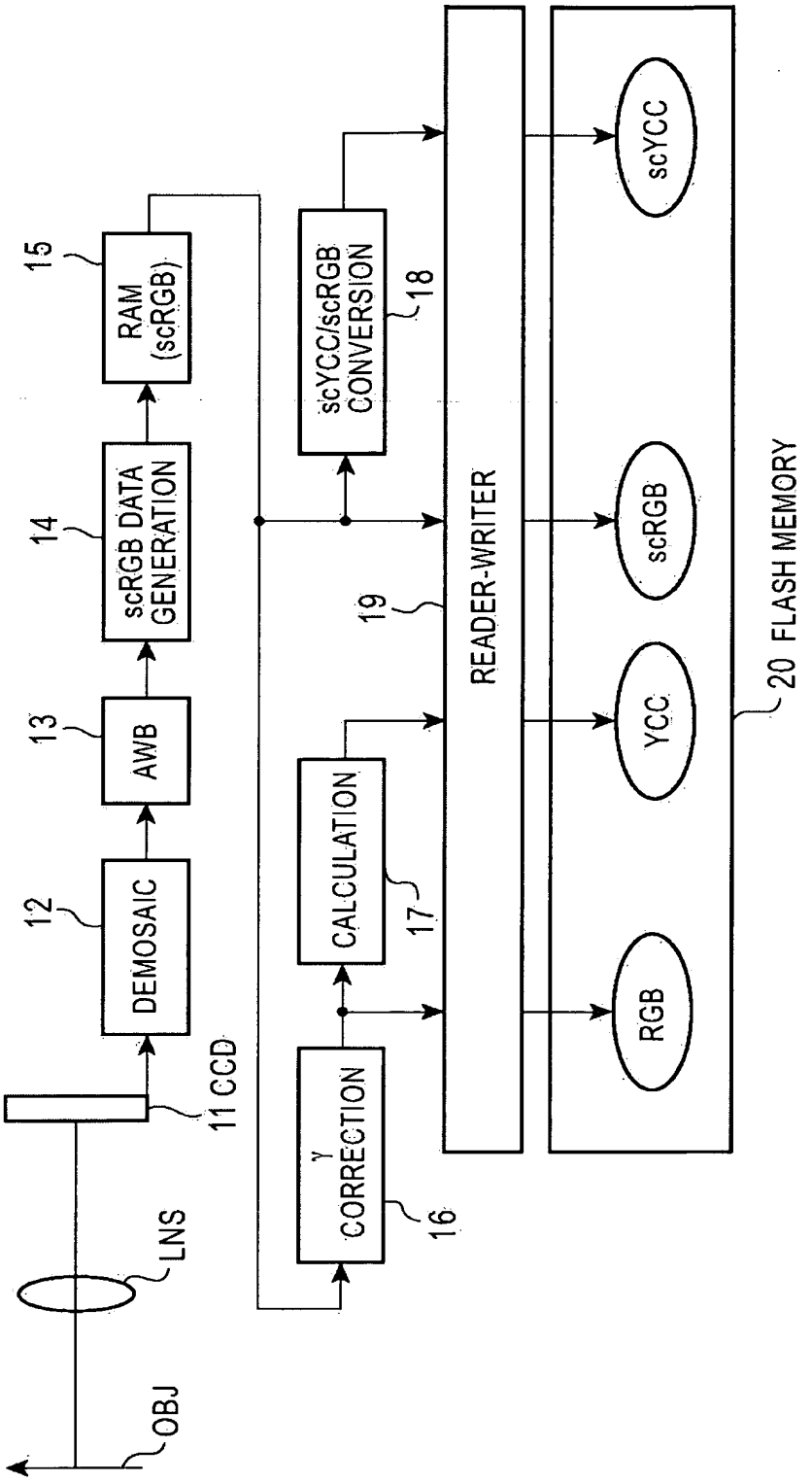
OBJ
LNS
11 CCD
12
DEMOSAIC
13
AWB
14
scRGB DATA GENERATION
15
RAM (scRGB)
γ CORRECTION
16
CALCULATION
17
scYCC/scRGB CONVERSION
18
19
READER-WRITER
RGB
YCC
scRGB
scYCC
20 FLASH MEMORY

FIG. 2

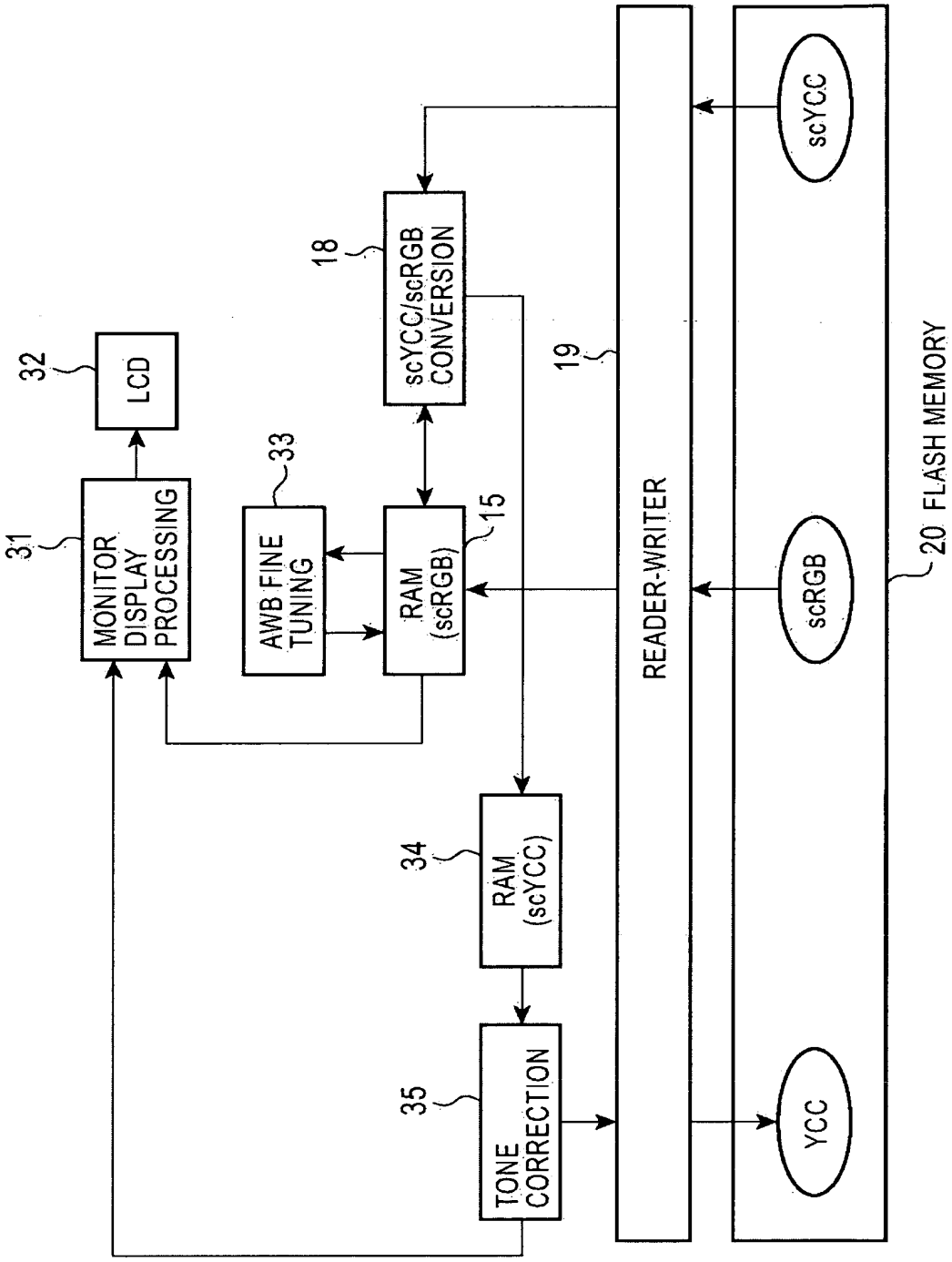
LCD
32
MONITOR DISPLAY PROCESSING
31
AWB FINE TUNING
33
RAM (scRGB)
15
scYCC/scRGB CONVERSION
18
19
READER-WRITER
scYCC
scRGB
YCC
20 FLASH MEMORY
RAM (scYCC)
34
TONE CORRECTION
35

FIG. 3

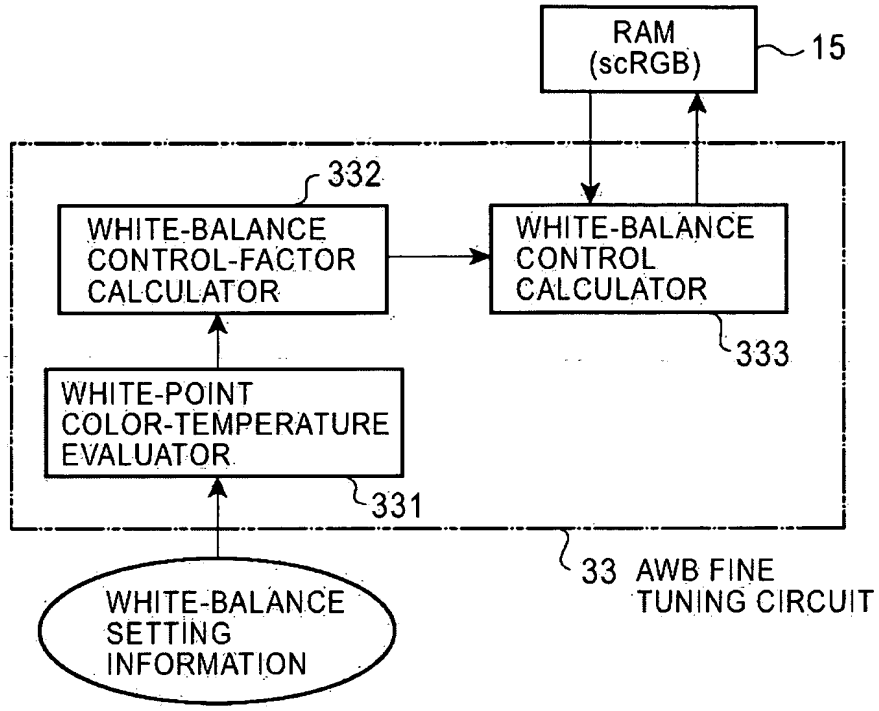
RAM
(scRGB)
15
332
WHITE-BALANCE
CONTROL-FACTOR
CALCULATOR
WHITE-BALANCE
CONTROL
CALCULATOR
333
WHITE-POINT
COLOR-TEMPERATURE
EVALUATOR
331
33 AWB FINE
TUNING CIRCUIT
WHITE-BALANCE
SETTING
INFORMATION

FIG. 4

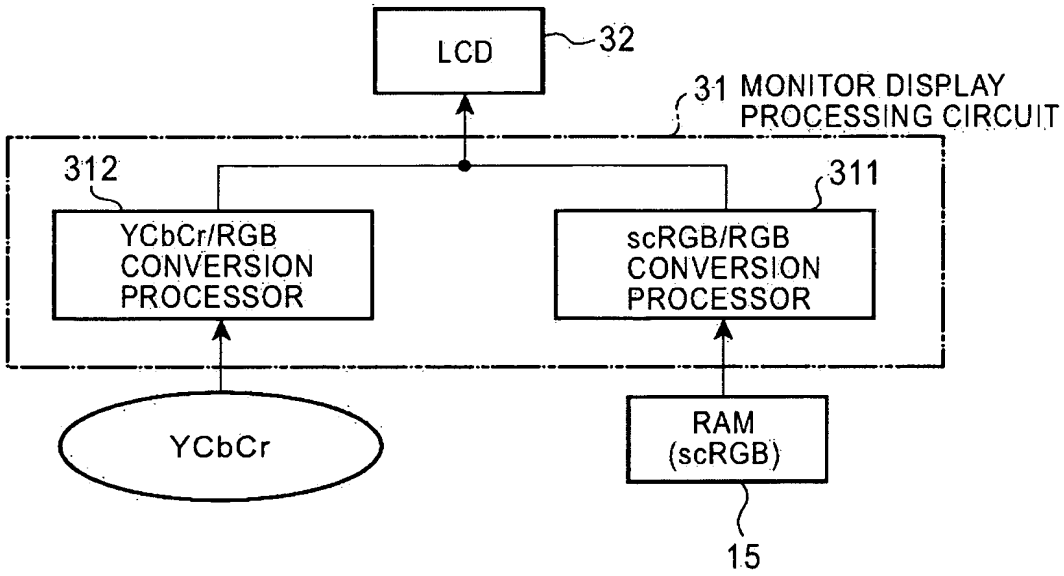
LCD
32
31 MONITOR DISPLAY
PROCESSING CIRCUIT
312
311
YCbCr/RGB
CONVERSION
PROCESSOR
scRGB/RGB
CONVERSION
PROCESSOR
YCbCr
RAM
(scRGB)
15

FIG. 5A

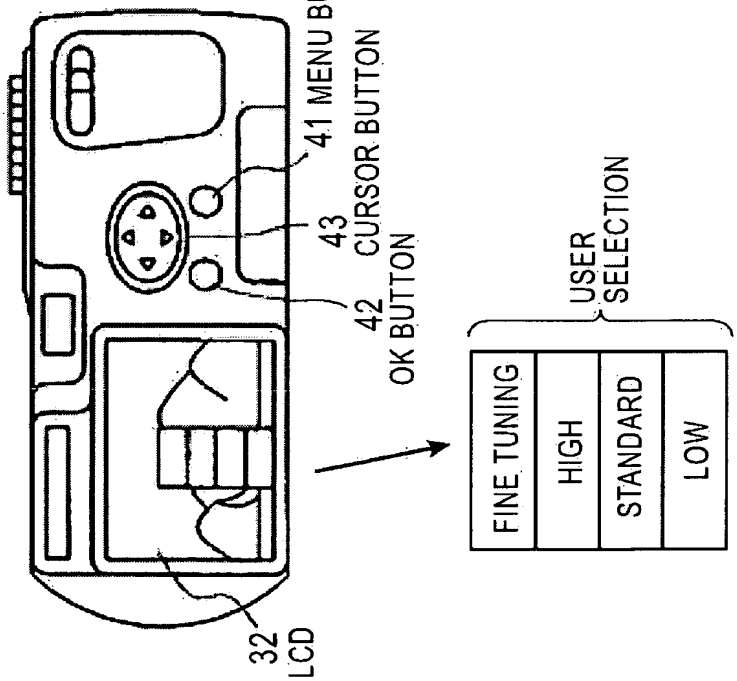
41 MENU BUTTON
43 CURSOR BUTTON
42 OK BUTTON
32 LCD
USER SELECTION
FINE TUNING
HIGH
STANDARD
LOW

FIG. 5B

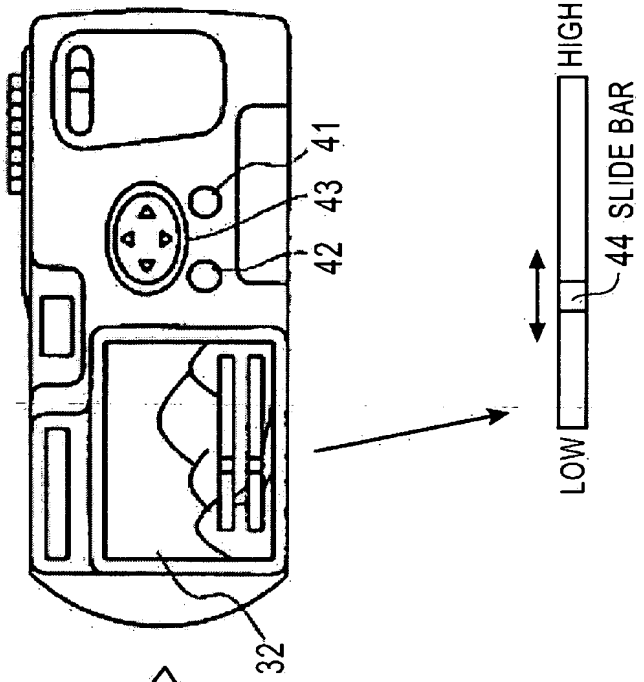
FINE TUNING
41
43
42
32
HIGH
44 SLIDE BAR
LOW

FIG. 6A

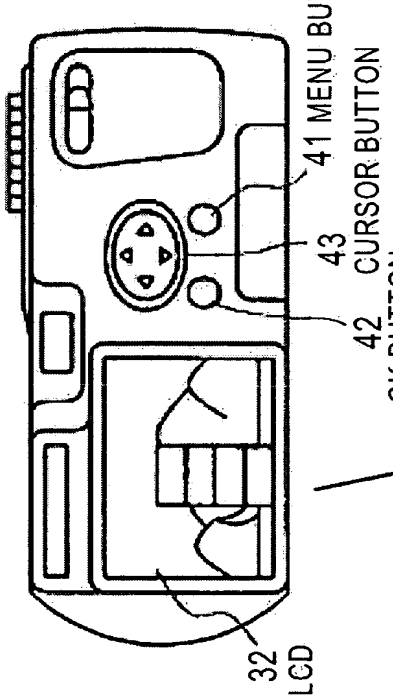

FIG. 6B

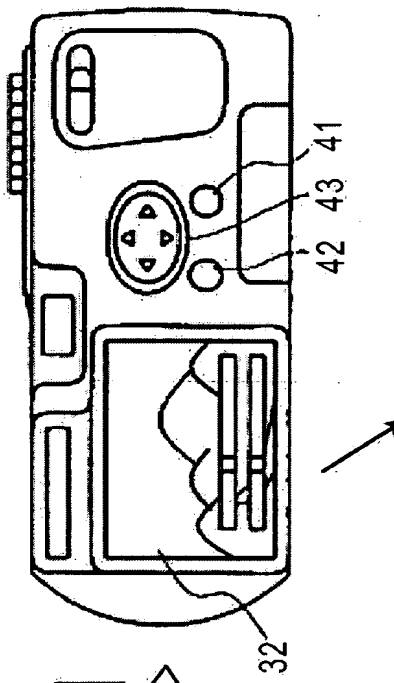

FIG. 6C

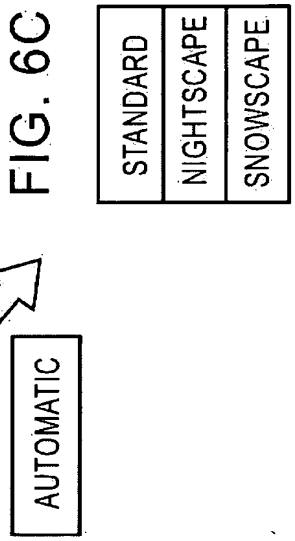

FIG. 7

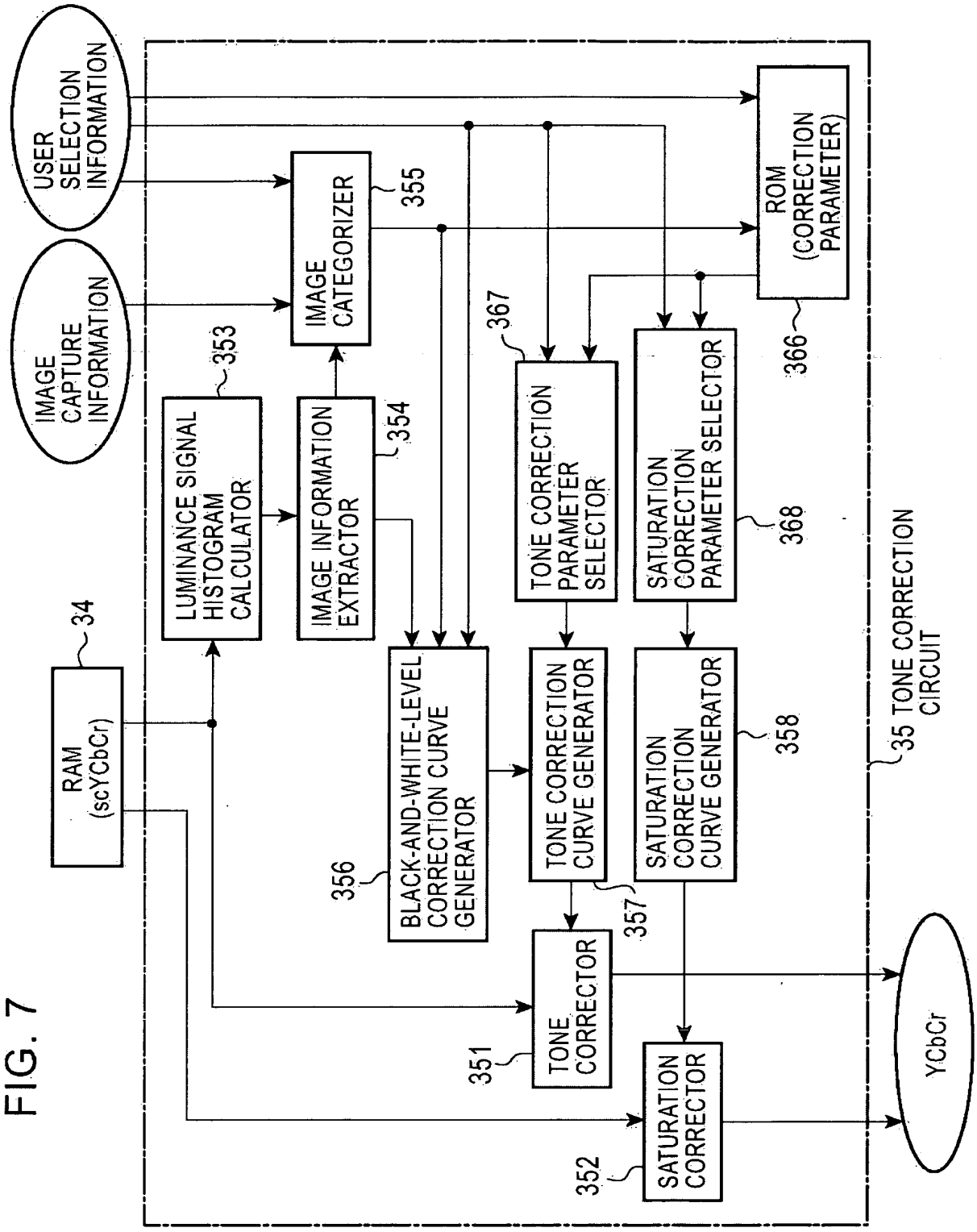
USER SELECTION INFORMATION
IMAGE CAPTURE INFORMATION
IMAGE CATEGORIZER
355
ROM (CORRECTION PARAMETER)
366
LUMINANCE SIGNAL HISTOGRAM CALCULATOR
353
IMAGE INFORMATION EXTRACTOR
354
TONE CORRECTION PARAMETER SELECTOR
367
SATURATION CORRECTION PARAMETER SELECTOR
368
34
RAM (scYCbCr)
BLACK-AND-WHITE-LEVEL CORRECTION CURVE GENERATOR
356
TONE CORRECTION CURVE GENERATOR
357
SATURATION CORRECTION CURVE GENERATOR
358
35 TONE CORRECTION CIRCUIT
TONE CORRECTOR
351
SATURATION CORRECTOR
352
YCbCr

FIG. 8

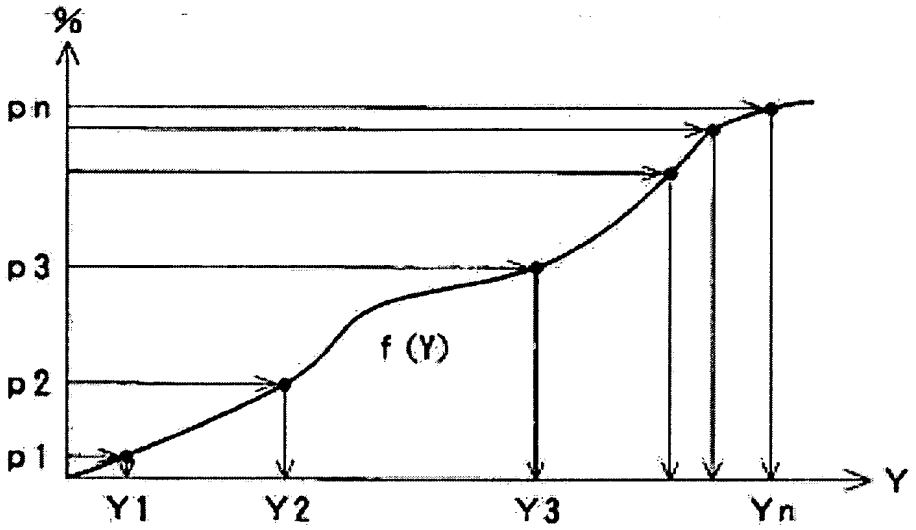

FIG. 9

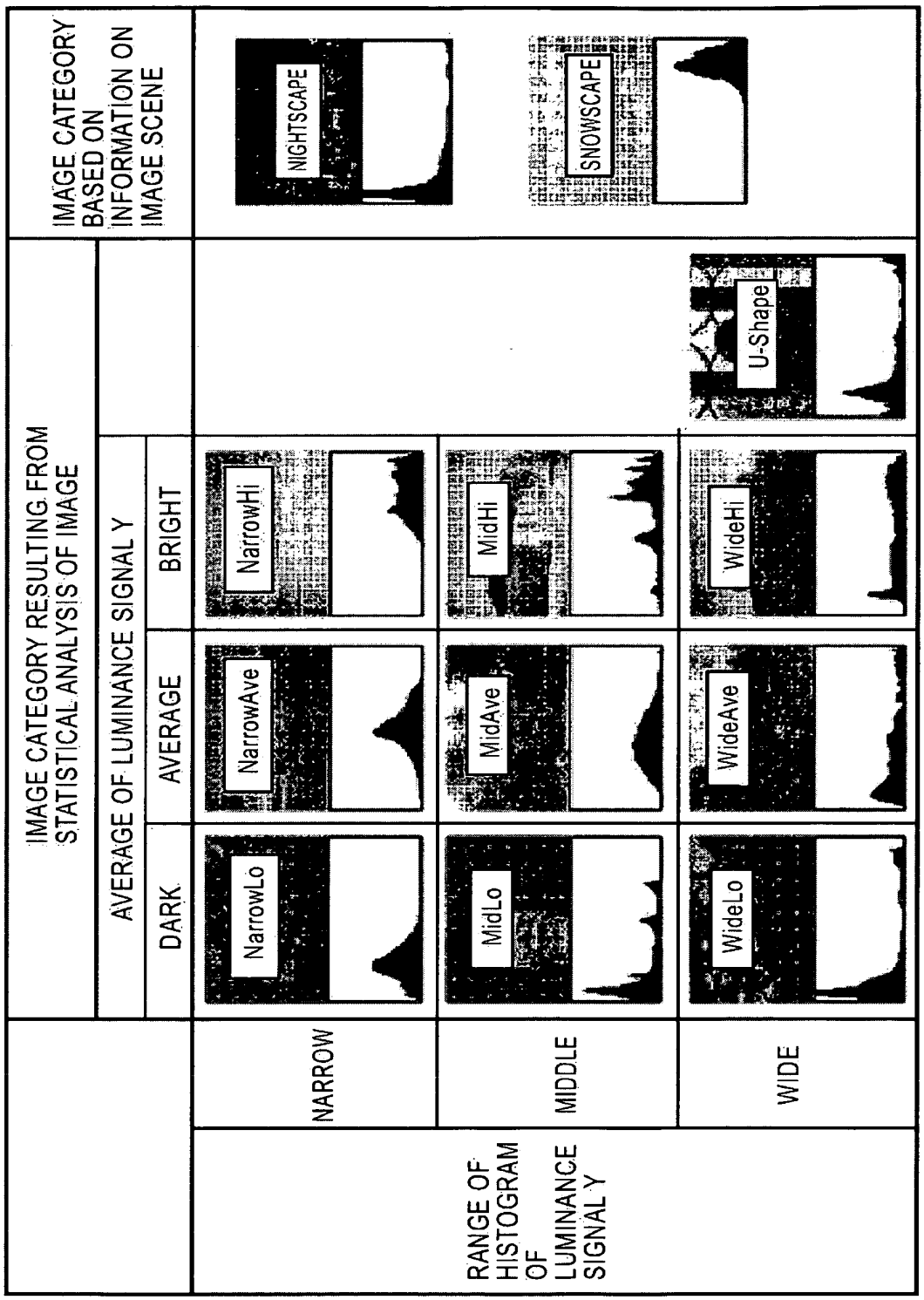
IMAGE CATEGORY RESULTING FROM STATISTICAL ANALYSIS OF IMAGE
AVERAGE OF LUMINANCE SIGNAL Y
DARK
AVERAGE
BRIGHT
IMAGE CATEGORY BASED ON INFORMATION ON IMAGE SCENE
RANGE OF HISTOGRAM OF LUMINANCE SIGNAL Y
NARROW
MIDDLE
WIDE
NarrowLo
NarrowAve
NarrowHi
MidLo
MidAve
MidHi
WideLo
WideAve
WideHi
U-Shape
NIGHTSCAPE
SNOWSCAPE

FIG. 10

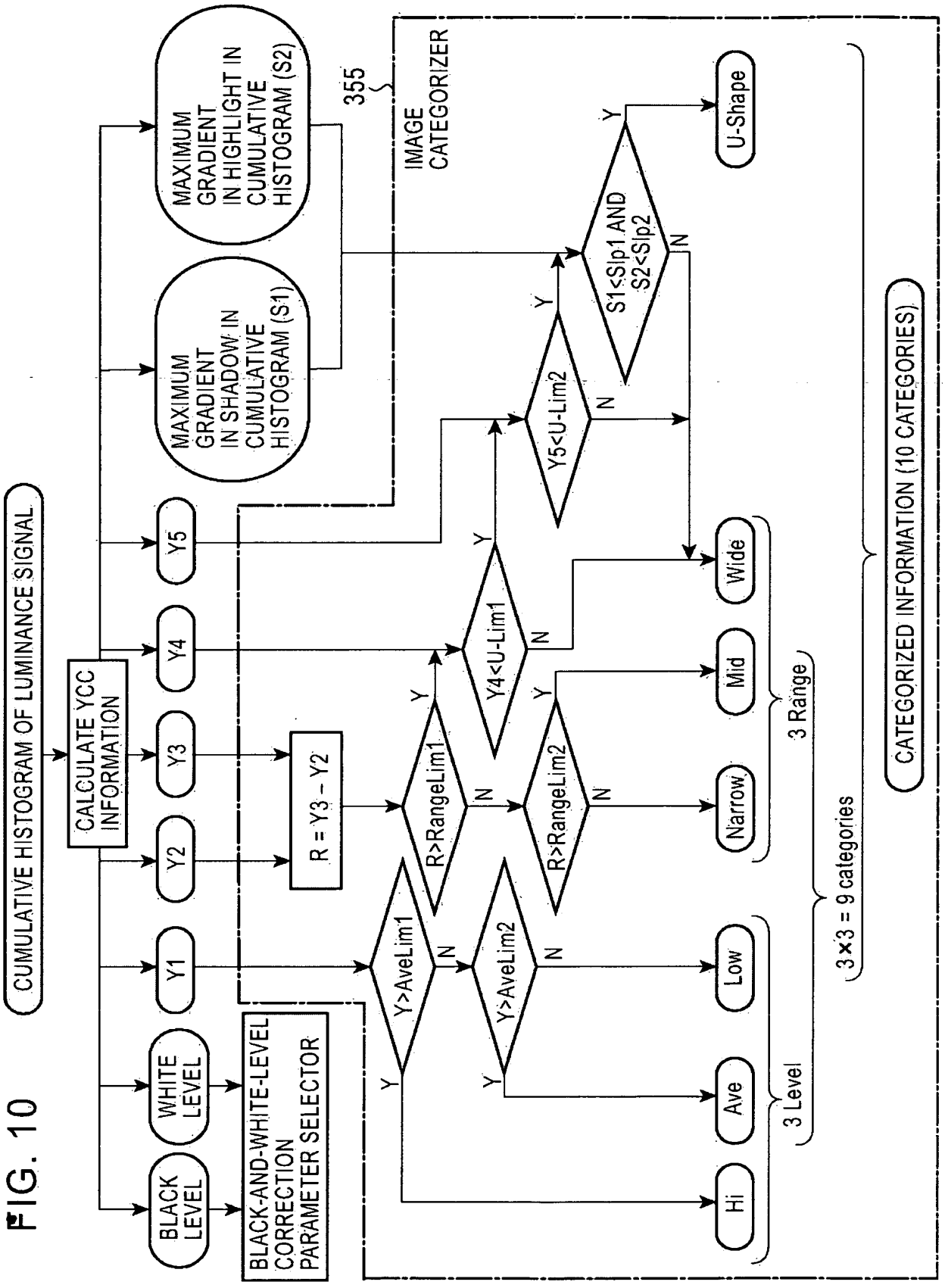
CUMULATIVE HISTOGRAM OF LUMINANCE SIGNAL
CALCULATE YCC INFORMATION
BLACK LEVEL
WHITE LEVEL
BLACK-AND-WHITE-LEVEL CORRECTION PARAMETER SELECTOR
Y1
Y2
Y3
Y4
Y5
R = Y3 – Y2
MAXIMUM GRADIENT IN SHADOW IN CUMULATIVE HISTOGRAM (S1)
MAXIMUM GRADIENT IN HIGHLIGHT IN CUMULATIVE HISTOGRAM (S2)
355
IMAGE CATEGORIZER
Y>AveLim1
Y>AveLim2
R>RangeLim1
R>RangeLim2
Y4<U-Lim1
Y5<U-Lim2
S1<Slp1 AND S2<Slp2
Y
N
Hi
Ave
Low
Wide
Mid
Narrow
U-Shape
3 Level
3 Range
3×3 = 9 categories
CATEGORIZED INFORMATION (10 CATEGORIES)

FIG. 11

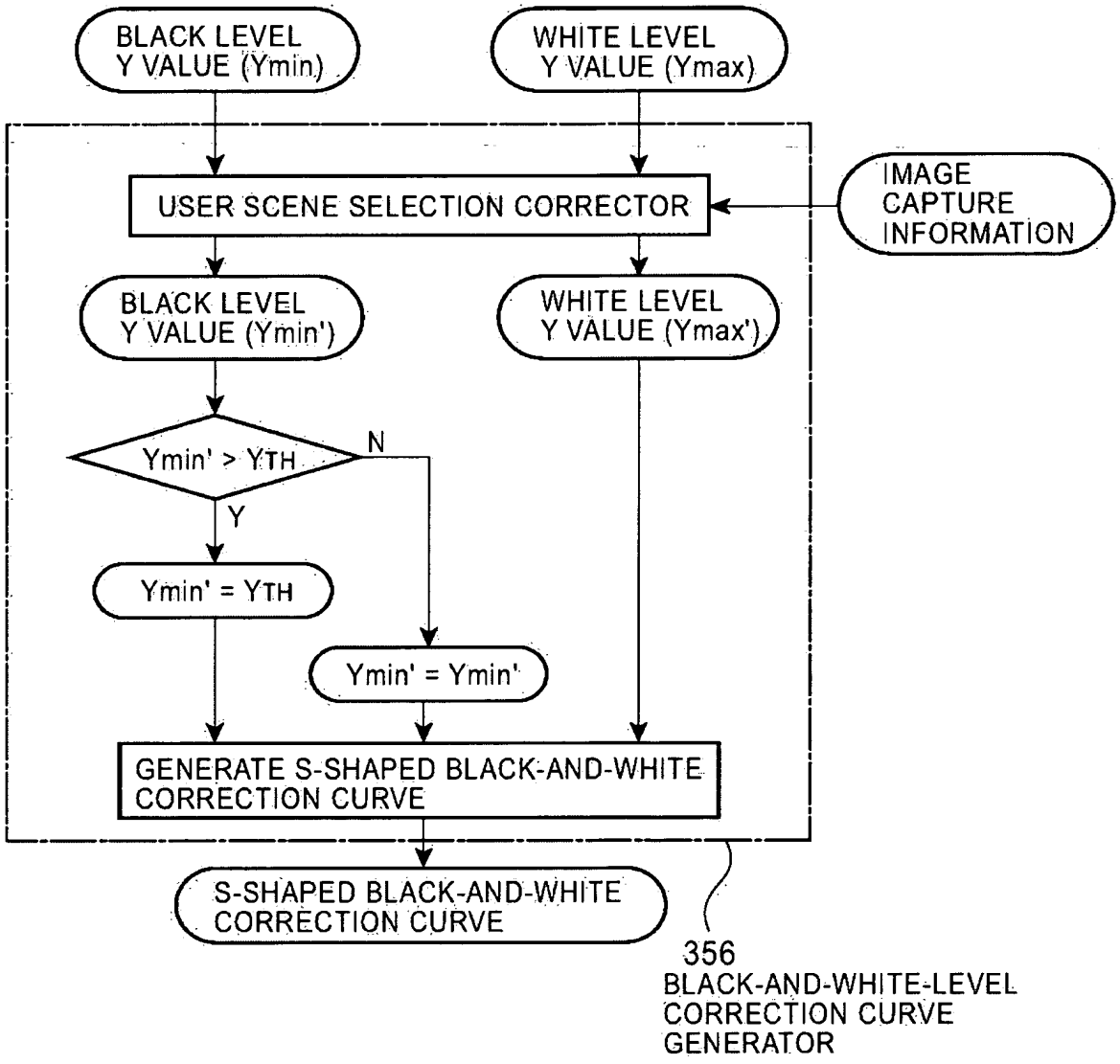
BLACK LEVEL Y VALUE (Ymin)
WHITE LEVEL Y VALUE (Ymax)
USER SCENE SELECTION CORRECTOR
IMAGE CAPTURE INFORMATION
BLACK LEVEL Y VALUE (Ymin')
WHITE LEVEL Y VALUE (Ymax')
Ymin' > YTH
N
Y
Ymin' = YTH
Ymin' = Ymin'
GENERATE S-SHAPED BLACK-AND-WHITE CORRECTION CURVE
S-SHAPED BLACK-AND-WHITE CORRECTION CURVE
356
BLACK-AND-WHITE-LEVEL CORRECTION CURVE GENERATOR

FIG. 12

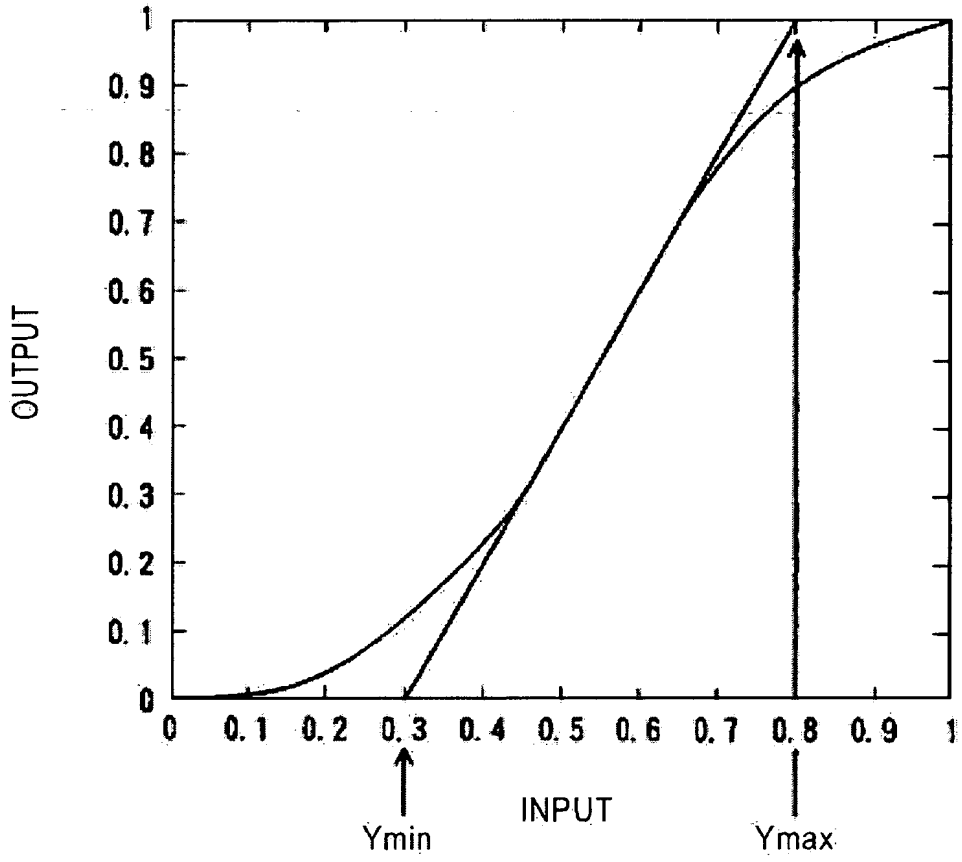
OUTPUT
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
INPUT
Ymin
Ymax

FIG. 13

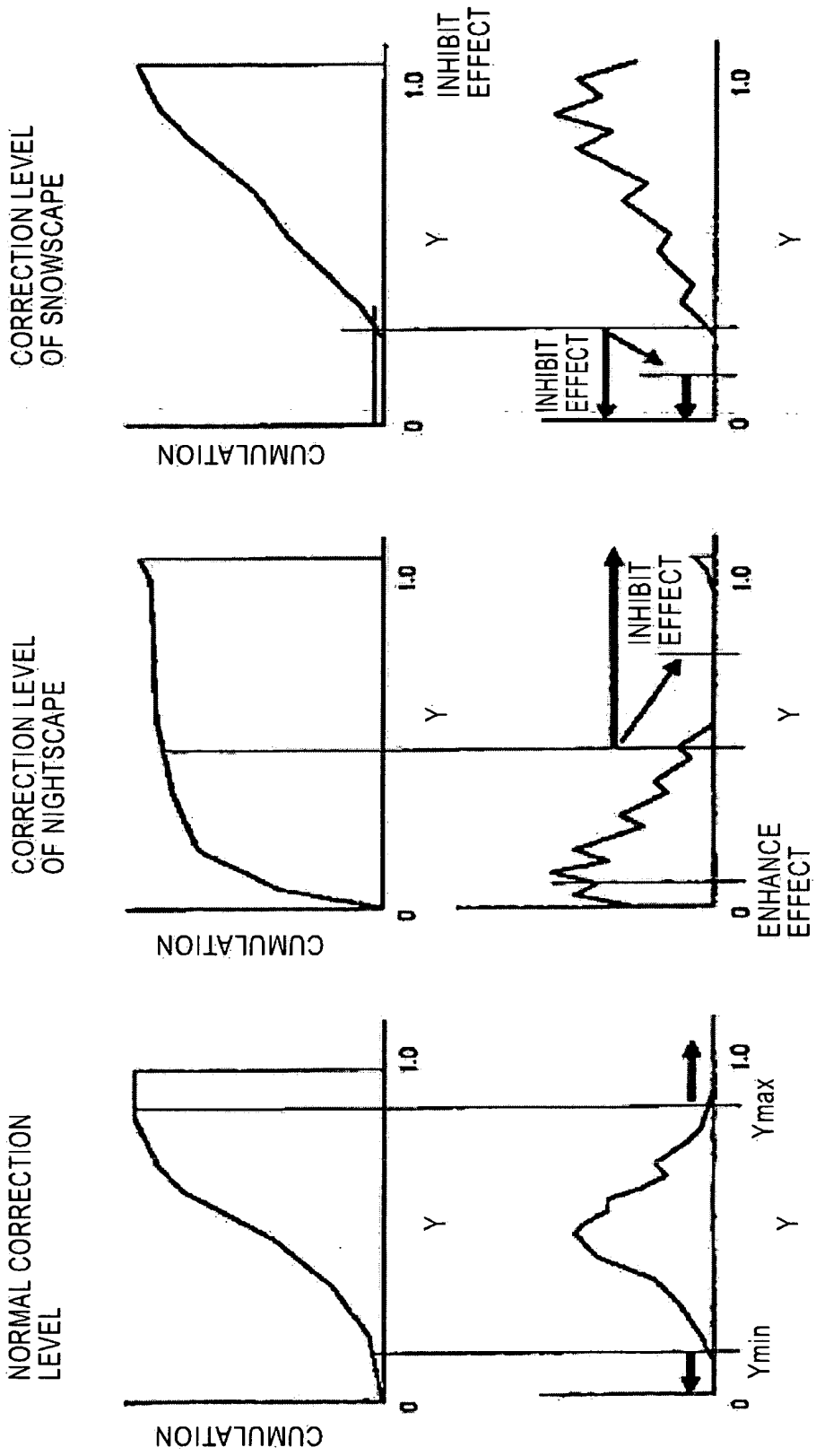
NORMAL CORRECTION LEVEL
CORRECTION LEVEL OF NIGHTSCAPE
CORRECTION LEVEL OF SNOWSCAPE
CUMULATION
1.0
0
Y
Ymax
Ymin
INHIBIT EFFECT
ENHANCE EFFECT

FIG. 14

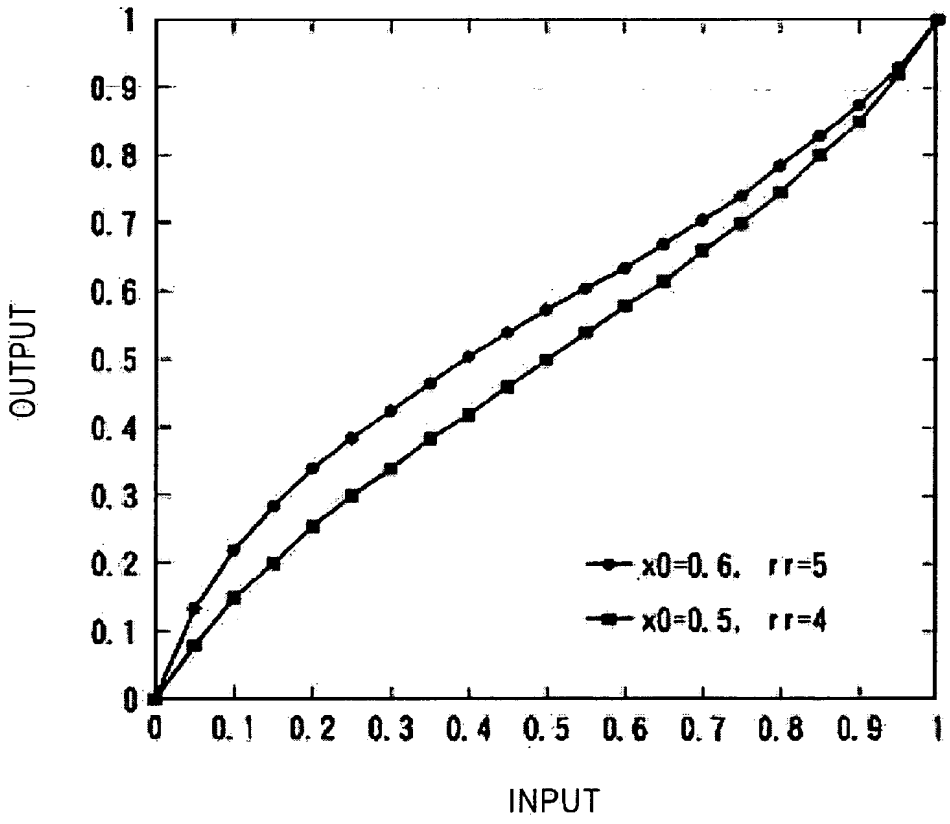

FIG. 15

	TONE CORRECTION PARAMETER		SATURATION CORRECTION PARAMETER
	x0	r r	k c
Narrow & Low	x0-NL	r r-NL	k c-NL
Narrow & Ave	x0-NA	r r-NA	k c-NA
Narrow & Hi	x0-NH	r r-NH	k c-NH
Mid & Low	x0-ML	r r-ML	k c-ML
Mid & Ave	x0-MA	r r-MA	k c-MA
Mid & Hi	x0-MH	r r-MH	k c-MH
Wide & Low	x0-WL	r r-WL	k c-WL
Wide & Ave	x0-WA	r r-WA	k c-WA
Wide & Hi	x0-WH	r r-WH	k c-WH
U-Shape	x0-U	r r-U	k c-U
NIGHTSCAPE	x0-N	r r-N	k c-N
SNOWSCAPE	x0-S	r r-S	k c-S

FIG. 16

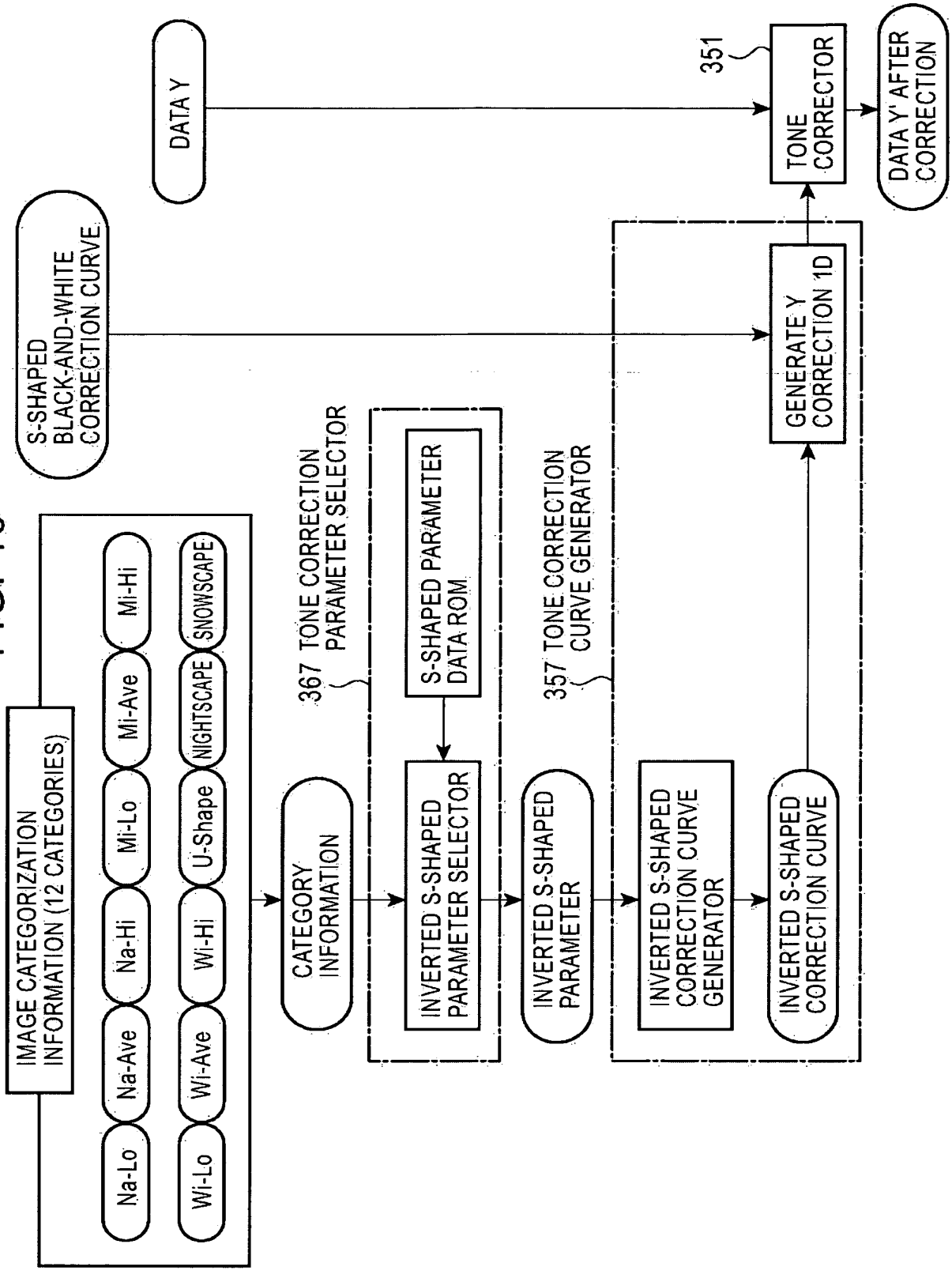
IMAGE CATEGORIZATION INFORMATION (12 CATEGORIES)
Na-Lo
Na-Ave
Na-Hi
Mi-Lo
Mi-Ave
Mi-Hi
Wi-Lo
Wi-Ave
Wi-Hi
U-Shape
NIGHTSCAPE
SNOWSCAPE
CATEGORY INFORMATION
367 TONE CORRECTION PARAMETER SELECTOR
S-SHAPED PARAMETER DATA ROM
INVERTED S-SHAPED PARAMETER SELECTOR
INVERTED S-SHAPED PARAMETER
357 TONE CORRECTION CURVE GENERATOR
INVERTED S-SHAPED CORRECTION CURVE GENERATOR
INVERTED S-SHAPED CORRECTION CURVE
GENERATE Y CORRECTION 1D
S-SHAPED BLACK-AND-WHITE CORRECTION CURVE
DATA Y
351
TONE CORRECTOR
DATA Y' AFTER CORRECTION

FIG. 17

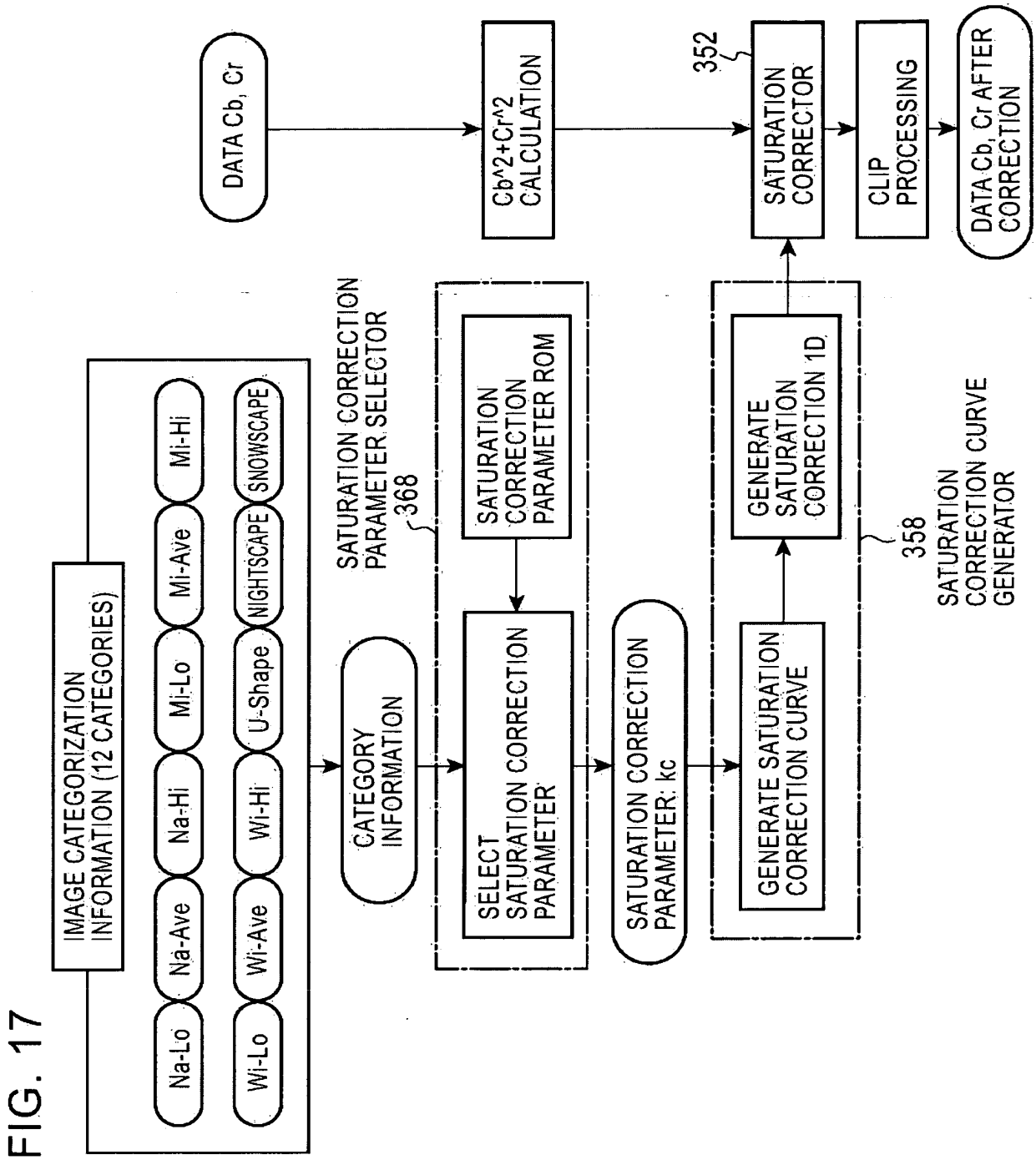
IMAGE CATEGORIZATION INFORMATION (12 CATEGORIES)
Na-Lo
Na-Ave
Na-Hi
Mi-Lo
Mi-Ave
Mi-Hi
Wi-Lo
Wi-Ave
Wi-Hi
U-Shape
NIGHTSCAPE
SNOWSCAPE
CATEGORY INFORMATION
SATURATION CORRECTION PARAMETER SELECTOR
368
SELECT SATURATION CORRECTION PARAMETER
SATURATION CORRECTION PARAMETER ROM
SATURATION CORRECTION PARAMETER: kc
GENERATE SATURATION CORRECTION CURVE
GENERATE SATURATION CORRECTION 1D
358
SATURATION CORRECTION CURVE GENERATOR
DATA Cb, Cr
Cb^2+Cr^2 CALCULATION
352
SATURATION CORRECTOR
CLIP PROCESSING
DATA Cb, Cr AFTER CORRECTION

FIG. 18

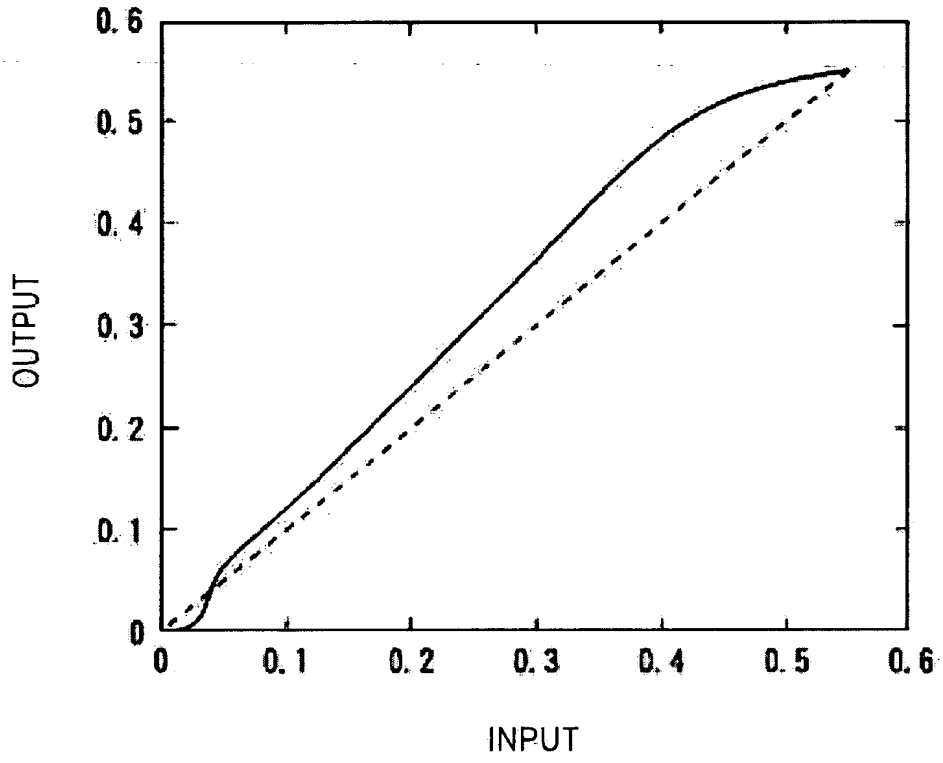

FIG. 19

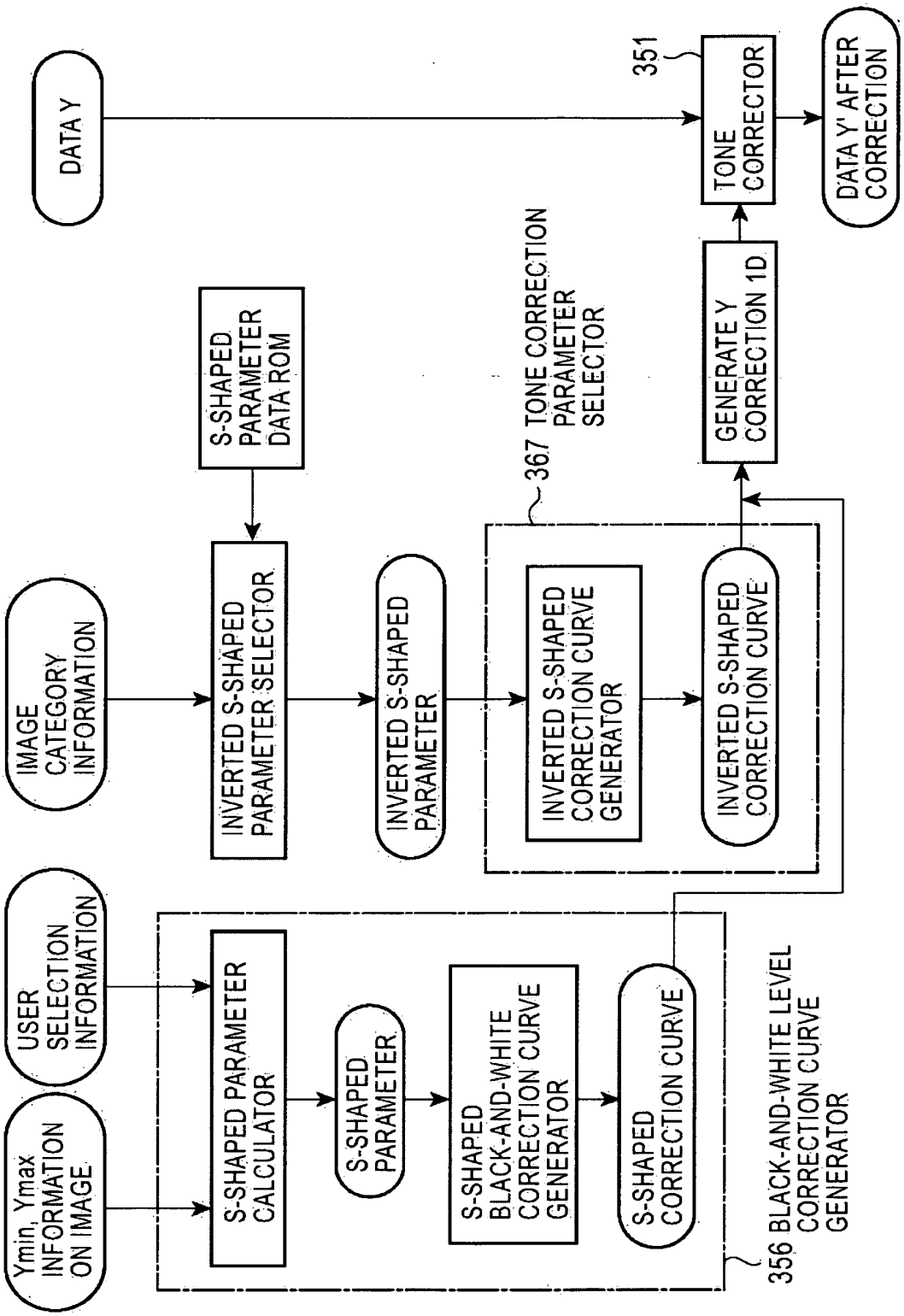
DATA Y
351
TONE CORRECTOR
DATA Y' AFTER CORRECTION
S-SHAPED PARAMETER DATA ROM
367 TONE CORRECTION PARAMETER SELECTOR
GENERATE Y CORRECTION 1D
IMAGE CATEGORY INFORMATION
INVERTED S-SHAPED PARAMETER SELECTOR
INVERTED S-SHAPED PARAMETER
INVERTED S-SHAPED CORRECTION CURVE GENERATOR
INVERTED S-SHAPED CORRECTION CURVE
USER SELECTION INFORMATION
Ymin, Ymax INFORMATION ON IMAGE
S-SHAPED PARAMETER CALCULATOR
S-SHAPED PARAMETER
S-SHAPED BLACK-AND-WHITE CORRECTION CURVE GENERATOR
S-SHAPED CORRECTION CURVE
356 BLACK-AND-WHITE LEVEL CORRECTION CURVE GENERATOR

FIG. 20

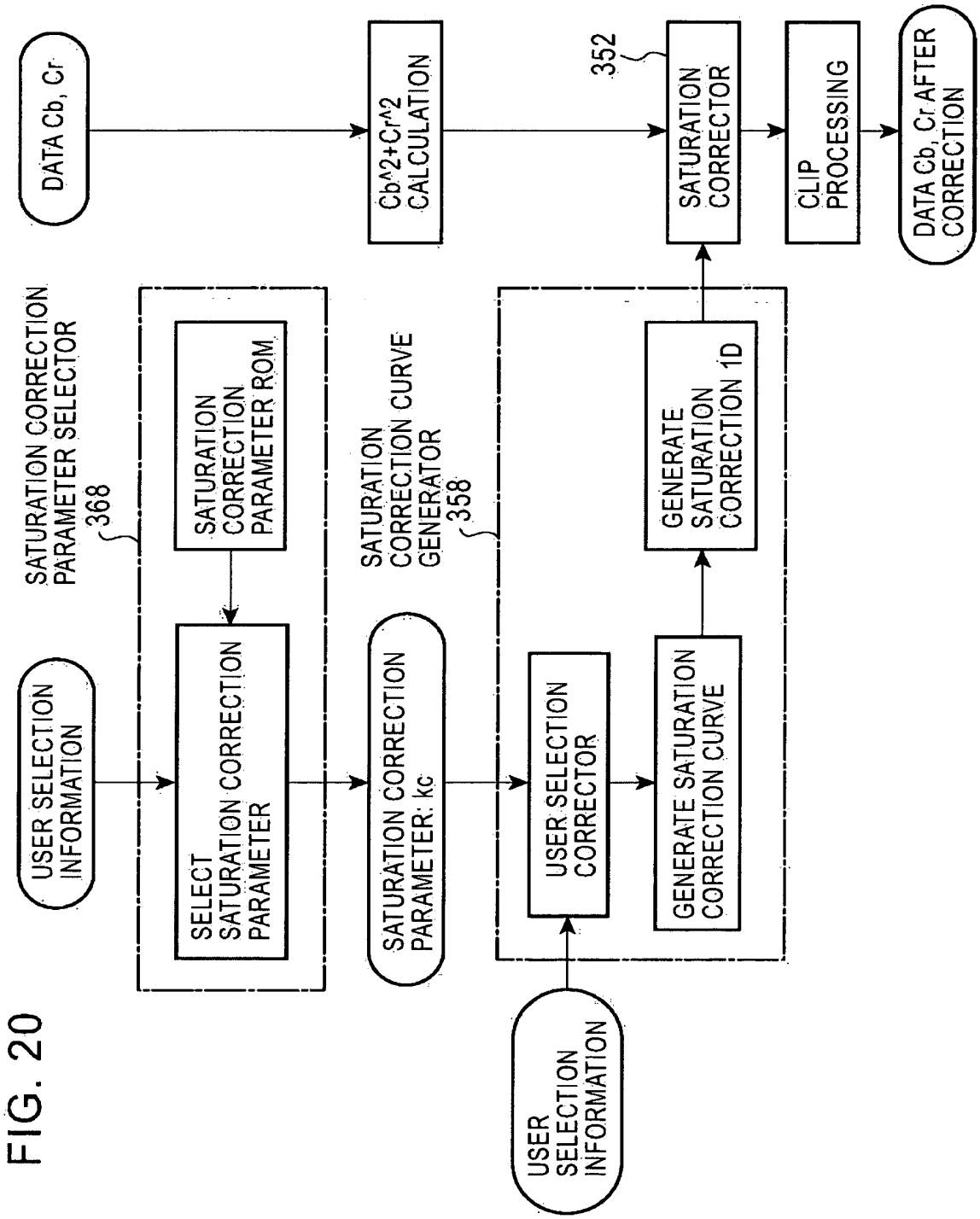
DATA Cb, Cr
Cb^2+Cr^2 CALCULATION
352
SATURATION CORRECTOR
CLIP PROCESSING
DATA Cb, Cr AFTER CORRECTION
SATURATION CORRECTION PARAMETER SELECTOR
368
SATURATION CORRECTION PARAMETER ROM
USER SELECTION INFORMATION
SELECT SATURATION CORRECTION PARAMETER
SATURATION CORRECTION PARAMETER: kc
SATURATION CORRECTION CURVE GENERATOR
358
GENERATE SATURATION CORRECTION 1D
USER SELECTION CORRECTOR
GENERATE SATURATION CORRECTION CURVE
USER SELECTION INFORMATION

FIG. 21

$$\begin{bmatrix} X_{raw} \\ Y_{raw} \\ Z_{raw} \end{bmatrix} = M1 \cdot \begin{bmatrix} R'2 \\ G'2 \\ B'2 \end{bmatrix} \quad \text{(EQUATION 1)}$$

$$M1 = \begin{bmatrix} 0.4124 & 0.3576 & 0.1805 \\ 0.2126 & 0.7152 & 0.0722 \\ 0.0193 & 0.1192 & 0.9505 \end{bmatrix}$$

$$\begin{bmatrix} X_{raw\_n} \\ Y_{raw\_n} \\ Z_{raw\_n} \end{bmatrix} = M2 \cdot \begin{bmatrix} X_{raw} \\ Y_{raw} \\ Z_{raw} \end{bmatrix} \quad \text{(EQUATION 2)}$$

WHERE

$$M2 = \begin{bmatrix} 1/(Y_{raw\_ave} \times 5) & 0 & 0 \\ 0 & 1/(Y_{raw\_ave} \times 5) & 0 \\ 0 & 0 & 1/(Y_{raw\_ave} \times 5) \end{bmatrix}$$

$$\begin{bmatrix} R'3 \\ G'3 \\ B'3 \end{bmatrix} = M1^{-1} \cdot \begin{bmatrix} X_{raw\_n} \\ Y_{raw\_n} \\ Z_{raw\_n} \end{bmatrix} \quad \text{(EQUATION 3)}$$

$$\begin{cases} R_{scRGB} = round[(R'3 \times 8192.0) + 4096.0] \\ G_{scRGB} = round[(G'3 \times 8192.0) + 4096.0] \\ B_{scRGB} = round[(B'3 \times 8192.0) + 4096.0] \end{cases} \quad \text{(EQUATION 4)}$$

$$\begin{cases} R'3 = (R_{scRGB} \div 8192.0) - 0.5 \\ G'3 = (G_{scRGB} \div 8192.0) - 0.5 \\ B'3 = (B_{scRGB} \div 8192.0) - 0.5 \end{cases} \quad \text{(EQUATION 5)}$$

FIG. 22

$R'3,\ G'3,\ B'3 \geqq 0.0031308$

$$\begin{cases} R'scRGB = 1.055 \times R'3^{(1.0/2.4)} - 0.055 \\ G'scRGB = 1.055 \times G'3^{(1.0/2.4)} - 0.055 \\ B'scRGB = 1.055 \times B'3^{(1.0/2.4)} - 0.055 \end{cases} \quad \text{(EQUATION 6-a)}$$

$0.0031308 > R'3,\ G'3,\ B'3 > -0.0031308$

$$\begin{cases} R'scRGB = 12.92 \times R'3 \\ G'scRGB = 12.92 \times G'3 \\ B'scRGB = 12.92 \times B'3 \end{cases} \quad \text{(EQUATION 6-b)}$$

$R'3,\ G'3,\ B'3 \leqq -0.0031308$

$$\begin{cases} R'scRGB = -1.055 \times (-R'3)^{(1.0/2.4)} + 0.055 \\ G'scRGB = -1.055 \times (-G'3)^{(1.0/2.4)} + 0.055 \\ B'scRGB = -1.055 \times (-B'3)^{(1.0/2.4)} + 0.055 \end{cases} \quad \text{(EQUATION 6-c)}$$

$$\begin{bmatrix} Y'scYCC \\ Cb'scYCC \\ Cr'scYCC \end{bmatrix} = M3 \cdot \begin{bmatrix} R'scRGB \\ G'scRGB \\ B'scRGB \end{bmatrix} \quad \text{(EQUATION 7)}$$

WHERE

$$M3 = \begin{bmatrix} 0.2990 & 0.5870 & 0.1140 \\ -0.1687 & -0.3313 & 0.5000 \\ 0.5000 & -0.4187 & -0.0813 \end{bmatrix}$$

$$\begin{cases} YscYCC = round[(Y'scYCC \times 1280) + 1024] \\ CbscYCC = round[(Cb'scYCC \times 2048) + 1024] \\ CrscYCC = round[(Cr'scYCC \times 2048) + 1024] \end{cases} \quad \text{(EQUATION 8)}$$

$$Tw' = Tw + \Delta T \quad \text{(EQUATION 9)}$$

FIG. 23

$$\begin{cases} x_d' = -4.6070\times10^{9}/T_w'^{3} + 2.9678\times10^{6}/T_w'^{2} \\ \qquad +0.09911\times10^{3}/T_w' + 0.244063 \\ y_d' = -3.000\times x_d'^{2} + 2.870\times x_d' - 0.275 \end{cases} \quad \text{(EQUATION 10)}$$

$$\begin{cases} X_w' = x_d'/y_d' \\ Y_w' = 1 \\ Z_w' = (1-x_d'-y_d')/y_d' \end{cases} \quad \text{(EQUATION 11)}$$

$$\begin{bmatrix} R'_w \\ G'_w \\ B'_w \end{bmatrix} = M1^{-1} \cdot \begin{bmatrix} X_w' \\ Y_w' \\ Z_w' \end{bmatrix} \quad \text{(EQUATION 12)}$$

$$\begin{cases} k_r = R'_w/R_w \\ k_g = G'_w/G_w \\ k_b = B'_w/B_w \end{cases} \quad \text{(EQUATION 13)}$$

$$\begin{cases} R_{scRGB\_T} = \mathrm{round}[k_r \times R_{scRGB}] \\ G_{scRGB\_T} = \mathrm{round}[k_g \times G_{scRGB}] \\ B_{scRGB\_T} = \mathrm{round}[k_b \times B_{scRGB}] \end{cases} \quad \text{(EQUATION 14)}$$

$$\begin{cases} Y'_{scYCC} = (Y'_{scYCC}-1024)/1280 \\ C_b'_{scYCC} = (C_b'_{scYCC}-2048)/1280 \\ C_r'_{scYCC} = (C_r'_{scYCC}-2048)/1280 \end{cases} \quad \text{(EQUATION 15)}$$

$$\begin{bmatrix} R'_{scRGB} \\ G'_{scRGB} \\ B'_{scRGB} \end{bmatrix} = M3^{-1} \cdot \begin{bmatrix} Y'_{scYCC} \\ C_b'_{scYCC} \\ C_r'_{scYCC} \end{bmatrix} \quad \text{(EQUATION 16)}$$

FIG. 24

$R'_{scRGB},\ G'_{scRGB},\ B'_{scRGB} \geqq 0.04045$

$$\begin{cases} R'3 = \left[\dfrac{R'_{scRGB} + 0.055}{1.055} \right]^{2.4} \\ G'3 = \left[\dfrac{G'_{scRGB} + 0.055}{1.055} \right]^{2.4} \\ B'3 = \left[\dfrac{B'_{scRGB} + 0.055}{1.055} \right]^{2.4} \end{cases} \quad \text{(EQUATION 17-a)}$$

$0.04045 > R'3,\ G'3,\ B'3 > -0.04045$

$$\begin{cases} R'3 = R'_{scRGB}/12.92 \\ G'3 = G'_{scRGB}/12.92 \\ B'3 = B'_{scRGB}/12.92 \end{cases} \quad \text{(EQUATION 17-b)}$$

$R'3,\ G'3,\ B'3 \leqq -0.04045$

$$\begin{cases} R'3 = -\left[\dfrac{(-R'_{scRGB}) + 0.055}{1.055} \right]^{2.4} \\ G'3 = -\left[\dfrac{(-G'_{scRGB}) + 0.055}{1.055} \right]^{2.4} \\ B'3 = -\left[\dfrac{(-B'_{scRGB}) + 0.055}{1.055} \right]^{2.4} \end{cases} \quad \text{(EQUATION 17-c)}$$

FIG. 25

$R'_{scRGB}, G'_{scRGB}, B'_{scRGB} < 0$

$$\begin{cases} R = 0 \\ G = 0 \\ B = 0 \end{cases} \quad \text{(EQUATION 18-a)}$$

$0 \leq R'_{scRGB}, G'_{scRGB}, B'_{scRGB} \leq 1.0$

$$\begin{cases} R = \mathrm{round}(R'_{scRGB} \times 255) \\ G = \mathrm{round}(G'_{scRGB} \times 255) \\ B = \mathrm{round}(B'_{scRGB} \times 255) \end{cases} \quad \text{(EQUATION 18-b)}$$

$1.0 < R'_{scRGB}, G'_{scRGB}, B'_{scRGB}$

$$\begin{cases} R = 255 \\ G = 255 \\ B = 255 \end{cases} \quad \text{(EQUATION 18-c)}$$

$$Sfwd(x) = \frac{1}{1 + e^{-rr(x-x0)}} \quad \text{(EQUATION 19-a)}$$

$$Yout = \frac{Sfwd(Yin) - Sfwd(0)}{Sfwd(1) - Sfwd(0)} \quad \text{(EQUATION 19-b)}$$

$$Sinv(x) = -\frac{1}{rr} \ln\left[\frac{1}{x} - 1\right] + x0 \quad \text{(EQUATION 20-a)}$$

$$Yout = \frac{Sinv(Yin) - Sinv(0)}{Sinv(1) - Sinv(0)} \quad \text{(EQUATION 20-b)}$$

$$Cout = kc \times Cin \quad \text{(EQUATION 21)}$$

$$Ycin\_TV = Ycin \times BKtv \quad \text{(EQUATION 22)}$$

FIG. 26

$$Ymax\_TV = Ymax \times Wtv \quad \text{(EQUATION 23)}$$

$$kc\_TV = kc \times Gtv \quad \text{(EQUATION 24)}$$

$$Ymax\_Pic = Ymax \times Wpic \quad \text{(EQUATION 25)}$$

$$kc\_Pic = kc \times Gpic \quad \text{(EQUATION 26)}$$

$$Ymin\_User = Ymin \times BKuser \quad \text{(EQUATION 27)}$$

$$Ymax\_User = Ymax \times Wuser \quad \text{(EQUATION 28)}$$

$$kc\_User = kc \times Guser \quad \text{(EQUATION 29)}$$

$$Guser = 2 - \frac{BKuser + Wuser}{2} \quad \text{(EQUATION 30)}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 255 & 0 & 0 \\ 0 & 255 & 0 \\ 0 & 0 & 255 \end{bmatrix} \cdot M3^{-1} \cdot \begin{bmatrix} Y' \\ Cb' \\ Cr' \end{bmatrix} \quad \text{(EQUATION 31)}$$